

the memoir published by me in 1873. Lister's observations led him to quite different conclusions, which he has since abandoned. I am sure that those who are at present busy in this country with the study of Bacteria, and who undertake to write hand-books of the subject, can have no desire to do otherwise than give a just statement of the history of knowledge of the organisms of which they treat. Hence it is with no unfriendly feeling that I offer to Mr. Crookshank and other writers similarly engaged the statement contained in this letter.

February 20

E. RAY LANKESTER

#### Notes on the Volcanic Phenomena of Central Madagascar

MADAGASCAR is as yet almost a *terra incognita* to the geologist; nothing, so far as I am aware, but notices of the most vague and fragmentary kind ever having appeared in regard to its geological features. Nor indeed may we expect to have other than the most general descriptions until the island is surveyed by thoroughly competent men. In the absence of something more complete, I hope that the following notes on the volcanic phenomena of Central Madagascar may not be unacceptable to your readers, and may prove a contribution, however slight, to our knowledge of the geology of this great island. And first let me mention the volcanic cones, of which there are many scores, probably hundreds, in the part of the island of which we are speaking. These volcanic cones are situated in two localities especially: in Mandridrano, on the western side of Lake Itasy, and in the neighbourhood of Betafo in Vakin' Ankaratra; the former being from 50 to 60 miles west, and the latter from 70 to 80 miles south-west, of Antananarivo, the capital. Both localities are about 130 miles from the sea on the eastern side of the island, and 150 on the western side. It is hardly necessary to say that all these volcanoes are extinct, and that there are none in activity at the present time in any part of Madagascar.<sup>1</sup> On the west side of Itasy the volcanic cones exist in great numbers, and these, therefore, shall be first described.

The extinct volcanoes of this district of Mandridrano extend for a distance of about 20 miles north and south, and perhaps 3 or 4 east and west. They are, for the most part, scoria cones. The cones are thickly studded over the district, in some parts clustering together more thickly than in others. There is no single large volcano to which the others are subsidiary, or upon which they are parasitic. Occasionally there is a series of cones which have evidently been heaped up by the simultaneous ejection of scoriae from different vents situated on the same line of fissure, but so that the cones have run one into the other, leaving a ridge, generally curvilinear, at the summit. None of these extinct volcanoes reach the height of 1000 feet. Kasige, which is probably the highest, I found by aneroid to be 863 feet above the plain (5893 feet above the sea). Andranonatoa is perhaps next in height to Kasige. Kasige is a remarkably perfect and fresh-looking volcano, whose sides slope at an angle of about 40°. The scoriae on the sides have become sufficiently disintegrated to form a soil on which are found a by no means scanty flora; for among other plants growing here I found an aloe (*A. macrolada*), and clematis (*C. trifida*), two or three Composite herbs (*Senecio cochlearifolius*, *Helichrysum lycopodioides*, *Laggera alata*, &c.), some grasses (*Imperata arundinacea*, &c.), a species of Indigofera, and an orchid. On its top is an unbreached crater, which measures, from the highest point of its rim, 243 feet in depth. It may be mentioned in passing, that on the very summit, in a hollow "cinder," there were found a small piece of money, perhaps of the value of a halfpenny, and a small bead, as also a portion of a banana leaf, with a few pieces of a manioc, and two or three earth-nuts placed upon

<sup>1</sup> Scrope, in his "Volcanoes," second edition, p. 428, says of Madagascar, "There is some reason to believe in the existence of active volcanic vents in this great island;" and Dr. Daubeny, in the second edition of his "Volcanoes," p. 433, in referring to the islands on the eastern coast of Africa, says: "The principal of these are the great Island of Madagascar, the Isle of Bourbon, and the Mauritius, the first of which has been too little explored to allow of my announcing with certainty anything respecting its physical structure;" and in a note he adds: "Madagascar is stated by Daubuisson to contain volcanoes, on the authority of Ebel (*Bau der Erde*, tome ii. p. 289), who reports that in this island there is a volcano ejecting a stream of water to a sufficient height to be visible 20 leagues out at sea." What remarkable eyesight those from whom Daubuisson heard the story must have had to see an invisible phenomenon so far away! Dr. Daubeny continues: "Sir Roderick Murchison, December 1827, exhibited at the Geological Society some specimens of a volcanic nature, said to have come from this island, but the locality was not mentioned."

it these had been deposited there by some of the heathen inhabitants of the place as a votive offering either to their ancestors or to the Vazimba (the aborigines of Central Madagascar). Continuous with Kasige, and adjoining its south side, though not so high, there is another volcano, Ambohimalala, and dozens of others are to be seen near by.

One thing with regard to these volcanic piles soon strikes the observer, which is, that they are frequently lop-sided, one side of the crater being higher than the other. The higher side varies from north to north-west and west. This is undoubtedly accounted for by the direction of the wind during the eruption, causing the ejected fragments to accumulate on the leeward side of the vent. Now we know that the south-east trades blow during the greater part of the year in Madagascar, hence the unequal development of the sides of the cones. The same thing may be also observed in the volcanic piles in the neighbourhood of Betafo. This phenomenon, as is well known, occurs also in other parts of the world.

A very large number of the cones have breached craters, whence lava has flowed in numerous streams and floods, covering the plains around. These streams and floods consist in every instance, I believe, of black basaltic lava; a sheet of this lava, the mingled streams of which have flowed from Ambohimalala and some other vents, has covered the plain at the foot of Kasige to such an extent as almost to surround the mountain. Similar sheets are to be seen in other parts of the district, but they are so much alike that a description of one will suffice for all. Amboditaimamo (or Ambohidratrimo?) is a small volcano to the north of Lake Itasy, and at the northern confines of the volcanic district. It possesses a breached crater turned towards the east; from this has issued a stream of lava which, following the direction of the lowest level of the ground, has swept through a small valley round the northern end of the mountain, and spread out at its west foot. This sheet of lava, which is horribly rough on the surface, occupies but a small area of some two or three square miles. It has been arrested in its flow in front by the side of the low hills. It is cut through in one part by a stream which, in some places, has worn a channel to the depth of 80 or 90 feet. Its surface, which is slightly cellular, is covered by some hundreds of mammiform hillocks, which must have been formed during the cooling of the liquid mass. The hillocks are mostly from 20 to 30 feet high, and apparently are heaped-up masses of lava, and not hollow blisters. The lava itself is black, heavy, and compact, being porphyritic with somewhat large crystals of augite. As yet it is scarcely decomposed sufficiently to form much of a soil, though grass grows on it abundantly, and a few other plants are to be seen.

A little to the south of Amboditaimamo there is another volcano, known by the name of Andrarivahy. It is situated on the summit of a ridge of hills—astride of it, so to speak—and from its crater there has been an outflow of what must have been very viscous lava, for, though the sides of the volcano and the ridge of hills form an angle of from 30° to 40°, the ejected matter has set or "guttered" on the slope, only a small portion of it having reached the valley below. This ridge of hills, through which the volcanic orifice has been drilled, is composed entirely of gneiss; and indeed it may be here stated that the whole of these volcanoes, as is the case also with those about Betafo, rest upon a platform of gneiss, chiefly garnetiferous.

Throughout the district numerous fragments of basic lava, trachyte, trachytic tuff, and basaltic conglomerate lie scattered about in abundance. The trachyte is of various shades of yellow and gray, and frequently porphyritic with large crystals of sardine. Pumice, obsidian, and pitchstone do not seem anywhere to be found.

In addition to the numerous scoria-cones, there may be seen here and there in the district some half-dozen or more bell-shaped hummocks of trachyte. They are for the most part composed of a light-coloured compact rock. This rock, having originally had a highly viscous or pasty consistency, has evidently accumulated, and set immediately over the orifice through which it was extruded; such hummocks are Ingolofotsy, Beteheza, Angavo, Ambasy, Isahadimy, Ambohibe, Antsahondra, &c. Ingolofotsy, situated to the north-west of Itasy, is perhaps the most striking in appearance of these trachytic hummocks. It bears some resemblance to a bell or Turkish fez, except that its sides are furrowed with water-channels and its truncated summit is notched in a remarkable manner. Its height above the plain is 665 feet (5258 feet above the sea); the inclination of its sides averages probably 50°. Adjoining Ingolofotsy on the south-

west is Beteheza, a large mass of trachyte which has probably welled out from an orifice on the same line of fissure from which Ingolofotsy was extruded. Angavo is another of these trachytic domes. One singular feature in this mountain is its numerous shallow water-channels, which make their way down from the summit in a surprisingly regular manner (at least on the north side), giving the appearance of an opened umbrella with numerous ribs. From one point of view I counted as many as thirty-four of these channels. It may be mentioned in passing that, in a valley at the west foot of Angavo, there is a small crater whose lips are level with the surface of the ground. This may perhaps be accounted for by supposing that the ejected materials from this and other craters near have so accumulated

almost perfect state of preservation in which most of the cones are still found, and by the undecomposed (or but slightly decomposed) character of the lava-streams that have issued from them. There have been no terrestrial disturbances or modifications of any magnitude since the days of their fiery energy; the conformation of hill and dale was the same then as now, for, in every instance, the lava-streams have adapted themselves to the form of the existing valleys.

Another feature worthy of mention in this volcanic district is the lakes and marshes which occupy many of the valleys. Itasy is the largest of the lakes, and Ifanja the largest of the marshes. Now most of these lakes and marshes have been doubtless formed by the sinking in of certain portions of the district, a fact made evident by the two following circumstances:—(a) On the south side of Kasige the gneiss may be seen distinctly to take a sudden dip beneath the volcanic pile, showing that, as the matter has been discharged from below, there has been a settling down of the cone, a fact made further evident by the existence of a small sheet of water, known as Bobojojo, in the immediate vicinity. But (b) on the western side of Ifanja marsh there is a small pond known as Mandentika. In the time of King Andrianampoinimerina, about a century ago, so the people say, there was a headland projecting into this pond, upon which was situated a small village of two or three houses. On a certain unhappy day the foundations of this headland suddenly gave way, and down it sank with the village and its inhabitants, only one of the latter escaping. From that time the pond has been appropriately termed Mandentika ("sinking"), but previous to the catastrophe it was known as Amparimboahangy. There is no doubt as to the truth of this story, as I have myself seen traces of the submerged headland and village appearing just above the surface of the water. The natives of the place say that the sinking was caused by a Fanamimpitoloa, a seven-headed, mythical, serpent-like monster that is supposed to live beneath the water.

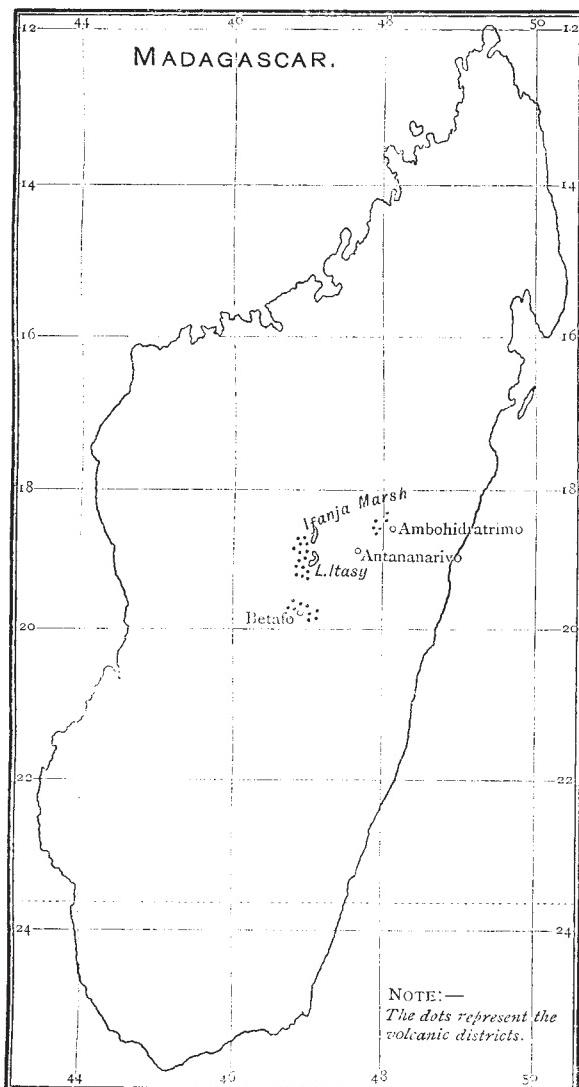
Ifanja Marsh is some four or five miles from one end to the other, and perhaps a mile or more wide in its greatest width. It runs in a northerly and southerly direction, with its southern end bending round towards the west, at the foot of which is the volcano of Amboditaimamo, mentioned above. The marsh is 3700 feet above the sea, forming a considerable depression below the surrounding country, which is about 5000 feet in altitude. At its south-eastern corner there are some hot springs which are much resorted to by sick folks.

Lake Itasy covers ground, roughly speaking, to the extent of about 25 square miles. It may not improbably occupy an area of depression due to volcanic action;<sup>1</sup> but be this as it may, there is a cause at its outlet sufficient to account for its formation. Here, lying in the river-bed, may be seen numerous blocks of gneiss, many of them blackened with a covering of oxide of iron; and beneath this gneiss lava may be seen. Several volcanoes cluster round the outlet; but there is one—an inconsiderable hill—situated on the southern margin of the outflowing river, just above the rapids. There distinctly enough may be seen a low and much-worn crater, with its breached side facing the outlet; and gneiss blocks may be traced from the bed of the river all up the hill-side to the crater. There has apparently been first an ejection of volcanic matter, followed probably by an explosion tearing up and flinging out the gneiss through which the vent was bored, hence the gneiss blocks are superimposed upon the lava. Thus the water has been ponded back. The river has now cut its way several feet through the barrier thus thrown across its course; and by this continual erosion at its outlet, and the accumulation of sediment, and the growth of vegetation at its head, the lake is slowly, though surely, decreasing in extent year by year.

It seems that the lava also occupies the bed of the river further down, as Mr. W. Johnson says: "Went down the Lilia as far as the waterfall at Ambohipo. A more beautiful fall I think I never saw. The river, broken into three streams, falls in foaming white masses over an edge of black lava some 50 feet deep. The whole bed of the river for a mile above is of the

<sup>1</sup> Mr. W. Johnson says: "I am told here that Itasy was once a huge swamp, and that its becoming a clear lake is within the knowledge, or perhaps the traditions, of the people." If this be really true, it can only be explained on the supposition that there has been a recent subsidence of what is now the bed of the lake, as in the case of Mandentika, mentioned above.

Mr. Sibree says: "The natives say that the lake Itasy . . . was formed by a Vazimba chieftain, named Rapeto, damming up a river in the vicinity and so the rice-fields of a neighboring chief w.th whom he was at variance were flooded, and have ever since remained under water."—"The Great African Island," p. 136.



as to raise the level of the valley between up to the rim of the crater, and so obliterate the cone, probably never of any great height.

It is hardly necessary to say that these extinct volcanoes of Mandridrano must have been in activity in comparatively recent times. Possibly they belong to the historic period, though no tradition lingers with regard to their being in a state of eruption.<sup>1</sup> That they are, at any rate, of recent date, is shown by the

<sup>1</sup> I was told by a native that near the village of Amboniriana, north of Angavo, and not far from Ingolofotsy, there is an emission of gas (? "fofona"), and that the people say that formerly fire was to be seen. The place is named Afotrona ("afó," fire; and "troná," grunting or hard breathing).

same black character, the lava broken in innumerable blocks, and setting out in vivid colour the verdure of the river banks."

A good deal of what has been said respecting the volcanic district of Itasy also holds good in regard to that of the Betafo valley and neighbourhood, where, however, the volcanic cones are fewer, and where trachytic domes do not appear to exist. One of the volcanoes in the Betafo valley, Iavoko, is of greater dimensions, and has a much larger crater than any to be found about Itasy. From this volcano a large sheet of basaltic lava has issued, upon which are to be found in abundance various species of plants, notably a Euphorbia and a stonecrop (*Kitchingia*). Almost all the plants growing on this lava-bed, however, are of a succulent character, and can dispense with soil, requiring merely a foothold. On the sides of Iavoko may be picked up fragments of calcined gneiss, which have been torn from the sides of the vent in the passage upward of the volcanic matter. On some of the cones numerous crystals of augite as large as marbles may be found among the volcanic debris. There is one volcano, Tritriva, near Betafo, which, inasmuch as it is different in character from any others mentioned above, deserves a few words. It is one of those volcanoes off which the summit has been blown by explosive action, leaving what is known as a crater-ring, which is now the site of a small lake. The lake is not more than 100 or 200 feet in diameter, perhaps not as much as that; but there is reason to suppose that it is of very great depth. The inner sides are steep for the greater part of the circumference, but on one side the lake is easily accessible.

It is possible that, when the country is more thoroughly explored, it may be found that the volcanoes near Itasy and those in the Betafo valley are connected by intermediate ones; indeed, on Dr. Mullens's map several craters are shown somewhat west of a straight line drawn between these two volcanic districts.

About 25 or 30 miles to the north-east of Antananarivo I discovered, a couple of years ago, several small volcanic craters. These also seem to belong to the class of crater-rings or explosion craters. Although fragments of volcanic matter have been ejected from them, they are not in such quantity as to form a cone; and the craters, none of which exceed 100 yards in diameter, and 30 feet in depth, have been formed probably by a single explosion of the pent-up forces below. With the exception of scoriae and lapilli, which are sparingly scattered about, there is no visible sign of volcanoes, and one may come to the very verge of the craters before being aware of their existence. Two of the largest craters consist of saucer-shaped depressions, but are rather elliptical than circular in form; the others consist mostly of small cavities, deep in proportion to their width. Several of the craters are occupied by sheets of water, with rushes and other aquatic plants growing around their margin.

Besides the volcanic phenomena mentioned above, thermal springs occur in various localities in the interior of Madagascar. The following is an analysis by Dr. Parker of water from springs in the district of Antsirabe:—

"On evaporation, one pint (20 oz.) of water from each spring yielded the following quantities of solid salts:—

Spring No. 1 yielded 40 grs. of salt, or 2 grs. to 1 oz. of water.

" " 2 "	38 "	1'9 "	1 "	"
" " 3 "	42 "	2'1 "	1 "	"
" " 4 "	28 "	1'4 "	1 "	"

All these springs contain the same ingredients, viz. lime, magnesia, soda, and potash, in combination with chlorine, iodine, sulphuric acid, and carbonic acid, with the addition of free carbonic acid gas."

At Antsirabe there is a deposit from one of these springs of carbonate of lime, which is occasionally used for building purposes in the capital. Bubbles of carbonic acid may be seen rising from the surface of the deposit, and at one point, where there is a small spring, a mass of calc-sinter has been formed which, speaking from memory, is probably 12 feet high by 18 feet long.

In one of the valleys in the vicinity of the crater-rings of Ambohidratrimo, spoken of above, there is a deposit of siliceous sinter. It appears in one or two places, scarcely rising above the surface of the ground, in a valley of rice-fields, and has been deposited by springs which have long since ceased to flow. The sinter is exceedingly hard and compact, and is used by the natives for fire-flints. In some portions of it numerous fossils of a species of *Equisetum* are embedded. The longitudinal

striæ leave no doubt as to the nature of the plant. The fistular stem has been filled in, and the vegetable substance entirely replaced, by silex. The stems of some of these fossil plants are quite half an inch in diameter. Now, the only *Equisetum* found in Central Madagascar at the present time is *E. ramosissimum*, but this never attains to such a thickness as the *Equiseta* in the sinter; so that the fossil species have become extinct since the springs which deposited the geyserite were in a state of activity.

So little is known respecting earthquake phenomena in Madagascar, no scientific observations ever having been instituted, that it is scarcely worth while to refer to the subject. However, it may be stated that scarcely a year passes without one or more shocks being experienced in Central Madagascar, though they are never severe or of long duration; and the destruction caused by these earth-waves in some parts of the world is entirely unknown here. The natives, I may say in passing, strangely imagine that earthquakes are caused by a whale (*Tropona*) turning on its back.

Extinct volcanoes and thermal springs exist also in other parts of the island, but so little is known about them that I can do no more than merely allude to their existence. R. BARON

Antananarivo, Madagascar, December 2, 1885

#### Coal-Dust and Explosions

THOSE who have given the labours and conclusions of workers antecedent to, and contemporaneous with, Mr. W. Galloway, on the subject of the part played by coal-dust in mine explosions, the careful consideration which these merit in common with the results and writings of that zealous exponent of the question, will hardly feel disposed to concur in his conclusion that, except by him, "the very simple, and yet all-important, element" to which he refers in his recent letter has been treated with neglect.

On the other hand, they will consider that when Mr. Galloway "goes the length of crediting coal-dust with the rôle of principal agent (in coal-mine explosions), and of relegating fire-damp to a secondary position," he altogether loses sight of some very obvious facts which forbid so sweeping a conclusion.

Any one who is led, by special interest in the subject, to study the forthcoming Report of the Royal Commission on Mine Accidents, will find that the important part which may be, and no doubt frequently is, taken by dust in coal-mine disasters is recognised to its full extent, and that, in a careful consideration of the accumulated knowledge on this subject, all due weight has been given to the experimental results arrived at by Mr. Galloway and others.

FREDK. A. ABEL

March 3

#### Deposits of the Nile Delta

PERMIT me to say that Prof. Judd is in error in supposing that I intended to withdraw my statement that desert sand underlies the Nile alluvium at a very moderate depth. The general succession of the newer deposits of Lower Egypt, according to the information I have been able to obtain (and which I have endeavoured to state as plainly as possible) is as follows, in descending order: (1) Modern alluvium, varying from zero to about 40 feet, and of course more in old eroded channels. (2) Desert sand of the Post-Glacial continental period. (3) Pleistocene or Isthmian deposits, lacustrine, estuarine, or marine. The question is not whether this succession exists—that I am prepared to argue on other grounds—but whether it appears in any or all of the recent borings. It is scarcely necessary to say that such general succession admits of alternations at the junctions of beds, and of local absence of some of its members. On finding, however, that the recent borings had been stopped by quicksand at the depth of about 35 feet, and that this quicksand consisted of the rounded grains of desert sand, and was mixed with gray clay or marl, and concretions like those of the Isthmian formation, I naturally concluded that the succession above referred to was distinctly indicated. Prof. Judd now affirms, as I understand, that, in all the Delta borings, mud of "precisely similar mineral character" to that of the surface extends to the bottom. The evidence of this, as well as the promised consideration of the other points to which I have alluded, I am content to wait for till the report appears in full.

J. WM. DAWSON

Montreal, February 18